

**Draft**

**Remedial Investigation  
Site-Specific Field Sampling Plan and  
Site-Specific Safety and Health Plan Attachments  
Former Choccolocco Corridor Ranges: Former Range 40,  
Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q;  
Former Range 41, Parcel 95Q and Impact Area, Choccolocco  
Corridor, Parcel 131Q-X; Former Range 42, Parcel 96Q, Range,  
Choccolocco Corridor, Parcel 145Q-X, and Impact Area,  
Choccolocco Corridor, Parcel 148Q-X; and Former Range 43,  
Parcel 97Q, Range, Choccolocco Corridor, Parcel 144Q-X, and  
Impact Area, Choccolocco Corridor, Parcel 147Q-X**

**Fort McClellan  
Calhoun County, Alabama**

**Task Order CK10  
Contract No. DACA21-96-D-0018  
Shaw Project No. 796887**

**May 2003**

**Revision 0**

**Draft  
Remedial Investigation  
Site-Specific Field Sampling Plan Attachment  
Former Choccolocco Corridor Ranges: Former Range 40,  
Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q;  
Former Range 41, Parcel 95Q and Impact Area, Choccolocco  
Corridor, Parcel 131Q-X; Former Range 42, Parcel 96Q, Range,  
Choccolocco Corridor, Parcel 145Q-X, and Impact Area,  
Choccolocco Corridor, Parcel 148Q-X; and Former Range 43,  
Parcel 97Q, Range, Choccolocco Corridor, Parcel 144Q-X, and  
Impact Area, Choccolocco Corridor, Parcel 147Q-X**

**Fort McClellan  
Calhoun County, Alabama**

**Prepared for:**

**U.S. Army Corps of Engineers, Mobile District  
109 St. Joseph Street,  
Mobile, Alabama 36602**

**Prepared by:**

**Shaw Environmental, Inc.  
312 Directors Drive  
Knoxville, Tennessee 37923**

**Task Order CK10  
Contract No. DACA21-96-D-0018  
Shaw Project No. 796887**

**May 2003**

**Revision 0**

# Table of Contents

---

	<i>Page</i>
List of Tables .....	iv
List of Figures .....	vi
List of Acronyms .....	vii
Executive Summary .....	ES-1
1.0 Project Description .....	1-1
1.1 Introduction .....	1-1
1.2 FTMC Site Description and History .....	1-2
1.3 Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels: Site Description and History .....	1-3
1.4 Regional and Site-Specific Geology .....	1-9
1.4.1 Regional Geology .....	1-9
1.4.2 Site-Specific Geology .....	1-13
1.5 Regional and Site-Specific Hydrogeology .....	1-15
1.5.1 Regional Hydrogeology .....	1-15
1.5.2 Site-Specific Hydrogeology .....	1-17
1.6 Scope of Work .....	1-17
2.0 Summary of Existing Environmental Studies .....	2-1
2.1 Site Investigation .....	2-2
2.1.1 Summary of Field Activities .....	2-3
2.1.2 Summary of Analytical Results .....	2-4
2.1.2.1 Surface Soil Analytical Results .....	2-5
2.1.2.2 Subsurface Soil Analytical Results .....	2-6
2.1.2.3 Groundwater Analytical Results .....	2-7
2.1.3 Surface Water .....	2-8
2.1.4 Sediment .....	2-9
2.1.5 SI Summary and Conclusions .....	2-9
3.0 Site-Specific Data Quality Objectives .....	3-1
3.1 Overview .....	3-1
3.2 Data Users and Available Data .....	3-1
3.3 Conceptual Site Exposure Model .....	3-2
3.3.1 Current site Use Receptors .....	3-2
3.3.2 Future Site Use Receptors .....	3-3
3.4 Decision-Making Process, Data Uses, and Needs .....	3-5
3.4.1 Risk Evaluation .....	3-5

## **Table of Contents** (Continued)

---

	<b>Page</b>
3.4.2 Data Types and Quality .....	3-6
3.4.3 Precision, Accuracy, and Completeness.....	3-6
4.0 Field Investigations .....	4-1
4.1 Utility Clearances .....	4-2
4.2 X-Ray Fluorescence Surface Soil Screening.....	4-3
4.3 Environmental Sampling .....	4-5
4.3.1 Surface Soil Sampling .....	4-5
4.3.1.1 Sample Locations and Rationale.....	4-5
4.3.1.2 Sample Collection .....	4-6
4.3.2 Subsurface Soil Sampling.....	4-6
4.3.2.1 Sample Locations and Rationale.....	4-6
4.3.2.2 Sample Collection .....	4-7
4.3.3 Monitoring Well Installation .....	4-8
4.3.3.1 Monitoring Well Locations and Rationale.....	4-8
4.3.3.2 Permanent Residuum Monitoring Wells.....	4-9
4.3.4 Groundwater Sampling.....	4-10
4.3.4.1 Sample Locations and Rationale.....	4-10
4.3.4.2 Sample Collection .....	4-10
4.3.5 Surface Water Sampling .....	4-10
4.3.5.1 Sample Locations and Rationale.....	4-11
4.3.5.2 Sample Collection .....	4-11
4.3.6 Sediment Sampling.....	4-11
4.3.6.1 Sample Locations and Rationale.....	4-11
4.3.6.2 Sample Collection .....	4-11
4.4 Decontamination Requirements .....	4-12
4.5 Surveying of Sample Locations.....	4-12
4.6 Analytical Program.....	4-12
4.7 Sample Preservation, Packaging, and Shipping .....	4-13
4.8 Investigation-Derived Waste Management .....	4-13
4.9 Site-Specific Safety and Health.....	4-14
5.0 Project Schedule.....	5-1
6.0 References .....	6-1

## ***Table of Contents*** *(Continued)*

---

Attachment 1 - List of Abbreviations and Acronyms

Attachment 2 - USACE Memorandum for Release of UXO Escort for Charlie Area of  
Fort McClellan

Appendix A - Boring Logs and Well Construction Logs

Appendix B - Survey Data

## **List of Tables**

---

<b>Table</b>	<b>Title</b>	<b>Follows Tab</b>
1-1	Groundwater Elevations and Well Construction Details	
2-1	Site Investigation Sampling Locations and Rationale, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-2	Groundwater and Surface Water Field Parameters	
2-3	Surface and Depositional Soil Analytical Results, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-4	Subsurface Soil Analytical Results, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-5	Groundwater Analytical Results, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-6	Surface Water Analytical Results, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-7	Sediment Analytical Results, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
3-1	Summary of Data Quality Objectives, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
4-1	XRF Grid Node and Range Fan Sample Locations, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
4-2	Proposed Sampling Locations and Rationale, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
4-3	XRF QA/QC Surface Soil Sample Designations and QA/QC Sample Quantities, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
4-4	Surface and Subsurface Soil Sample Designations and QA/QC Sample Quantities, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
4-5	Groundwater Sample Designations and QA/QC Sample Quantities, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	

## **List of Tables** (Continued)

---

<b>Table</b>	<b>Title</b>	<b>Follows Tab</b>
4-6	Surface Water and Sediment Sample Designations and QA/QC Sample Quantities, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
4-7	Analytical Samples, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	

## **List of Figures**

---

<b>Figure</b>	<b>Title</b>	<b>Follows Tab</b>
1-1	Site Location Map, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
1-2	Site Map, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
1-3	Site Geologic Map, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
1-4	Groundwater Elevation Map, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-1	Existing Sample Location Map, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	
2-2	Estimated Lead Concentration Isopleths for Surface and Depositional Soil	
3-1	Human Health Conceptual Site Exposure Model	
3-2	Ecological Conceptual Site Exposure Model	
4-1	Proposed XRF Sample Location Grid Map	
4-2	Proposed Range Fan XRF Sample Locations	
4-3	Proposed Sample Location Map, Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels	

## ***List of Acronyms***

---

See Attachment 1 – List of Abbreviations and Acronyms.

## ***Executive Summary***

---

In accordance with Contract Number DACA21-96-D-0018, Task Order CK10, Shaw Environmental, Inc. (Shaw) (formerly IT Corporation) will conduct a remedial investigation (RI) at the Former Choccolocco Corridor Ranges: Former Range 40, Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q; Former Range 41, Parcel 95Q and Impact Area, Choccolocco Corridor, Parcel 131Q-X; Former Range 42, Parcel 96Q, Range, Choccolocco Corridor, Parcel 145Q-X, and Impact Area, Choccolocco Corridor, Parcel 148Q-X; and Former Range 43, Parcel 97Q, Range, Choccolocco Corridor, Parcel 144Q-X, and Impact Area, Choccolocco Corridor, Parcel 147Q-X (Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels) at Fort McClellan (FTMC), Calhoun County, Alabama. The RI will determine the nature and extent of contamination resulting from U.S. Army training activities that occurred at the site. The purpose of this site-specific RI field sampling plan is to provide technical guidance for the sampling activities proposed at the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels.

The Former Choccolocco Corridor Ranges includes the following four sets of ranges and parcels:

- Former Range 40, Parcel 94Q; and Range, Choccolocco Corridor, Parcel 146Q
- Former Range 41, Parcel 95Q; and Impact Area, Parcel 131Q-X
- Former Range 42, Parcel 96Q; Range, Choccolocco Corridor, Parcel 145Q-X; and Impact Area, Choccolocco Corridor, Parcel 148Q-X
- Former Range 43, Parcel 97Q; Range, Choccolocco Corridor, Parcel 144Q-X; and Impact Area, Choccolocco Corridor, Parcel 147Q-X.

The Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels are located west of the Choccolocco Mountains in Choccolocco Corridor near the eastern boundary of the FTMC Main Post and were part of the Range 40 complex. The Choccolocco Corridor was leased by the U.S. government from the State of Alabama from 1941 until 1998. The Choccolocco Corridor lease was terminated in May 1998, and the land is currently managed by the Alabama Forestry Commission.

Site investigation (SI) field activities conducted by Shaw at the Former Choccolocco Corridor Ranges consisted of the collection and analysis of 72 surface soil samples, 17 depositional soil samples, 70 subsurface soil samples, 12 groundwater samples, 3 surface water samples, and 3

1 sediment samples. In addition, 15 monitoring wells were installed to facilitate groundwater  
2 sample collection and to provide site-specific geological and hydrogeological characterization  
3 information.

4  
5 Comparison of the analytical data to the site-specific screening levels (SSSL), ecological  
6 screening values, and background values indicates the human health chemicals of potential  
7 concern at the Former Choccolocco Corridor Ranges are 11 metals (aluminum, antimony,  
8 barium, cadmium, chromium, copper, iron, lead, manganese, thallium, and zinc) and one  
9 explosive compound (2,4-dinitrotoluene) in surface and depositional soils; 8 metals (aluminum,  
10 antimony, chromium, iron, lead, manganese, thallium, and vanadium) in subsurface soil; and  
11 manganese in groundwater. The most significant chemical of potential concern is lead, which  
12 was detected at concentrations (401 to 4,640 milligrams per kilogram) exceeding its residential  
13 SSSL (400 milligrams per kilogram) in 19 surface soil samples and 2 subsurface soil samples.  
14 Volatile organic compounds, semivolatile organic compounds, herbicides, and pesticides in site  
15 media were below SSSLs.

16  
17 Constituents of potential ecological concern (COPEC) include 15 metals (aluminum, antimony,  
18 barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury,  
19 selenium, thallium, and zinc), 9 pesticides (4,4'-dichlorodiphenyldichloroethene [DDE], 4,4'-  
20 dichlorodiphenyltrichloroethane (DDT), aldrin, alpha-betahexachlorocyclohexane [BHC], beta-  
21 BHC, dieldrin, endrin, gamma-BHC, and methoxychlor), one herbicide (propionic acid  
22 [MCP]), and one explosive compound (2,4-dinitrotoluene) in surface soil; and copper in  
23 sediment. No COPECs were identified in surface water.

24  
25 Based on the results of the SIs, past training operations at the Former Choccolocco Corridor  
26 Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels appear to have adversely impacted  
27 the environment. The contaminants detected in soil may pose an unacceptable risk to human  
28 health and the environment. The SI data for the Former Choccolocco Corridor Ranges were  
29 presented to the Base Realignment and Closure Cleanup Team (BCT) in January 2003.  
30 Therefore, the BCT recommended that the nature and extent of the metals contamination in soil  
31 be defined at the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and  
32 Associated Parcels. Also, the BCT agreed that the existing monitoring wells at the Former  
33 Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels will be  
34 resampled to verify the previous SI results and that additional monitoring wells will be installed  
35 and sampled to determine if contaminants are present. Because of proximity of the ranges and  
36 because lead contamination was found in surface soil at each of the four sites, the BCT  
37 recommended combining the four range areas into one RI.

1 Shaw will conduct x-ray fluorescence (XRF) screening of surface soil for lead at approximately  
2 700 locations to better define locations for soil borings. In addition, Shaw will collect 25  
3 groundwater samples (10 proposed and 15 existing locations), 100 surface soil samples, 100  
4 subsurface soil samples, 30 surface water samples, and 30 sediment samples at this site.  
5 Potential contaminant sources at the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q,  
6 96Q, 97Q, and Associated Parcels include primarily metals. Chemical analyses of selected  
7 samples collected during the field program will include volatile organic compounds, semivolatile  
8 organic compounds, metals, nitroaromatic/nitramine explosives, chlorinated and  
9 organophosphorus pesticides, chlorinated herbicides, and polychlorinated biphenyls. Results  
10 from these analyses will be compared with SSSLs, ecological screening values, and background  
11 values to determine if potential site-specific chemicals are present at the site at concentrations  
12 that pose an unacceptable risk to human health or the environment.

13  
14 This RI field sampling plan will be used in conjunction with the installation-wide sampling and  
15 analysis plan, and the site-specific safety and health plan. The sampling and analysis plan  
16 includes the installation-wide safety and health plan, monitoring well installation and  
17 maintenance plan, investigation-derived waste management plan, ordnance and explosives (OE)  
18 management plan, and quality assurance plan. Site-specific hazard analyses are included in the  
19 site-specific safety and health plan attachment.

20  
21 Foster Wheeler Environmental Corporation conducted an OE engineering evaluation/cost  
22 analysis (EE/CA) investigation in 2002 and 2003. The purpose of the EE/CA was to investigate  
23 the nature and extent of unexploded ordnance (UXO) and OE in Charlie Area (includes  
24 Choccolocco Corridor) on FTMC. Based on the results of the field work, USACE-Huntsville  
25 Center has issued an internal draft EE/CA report that states that neither UXO nor OE was found  
26 within Choccolocco Corridor. Therefore, the USACE-Huntsville Center issued a memorandum  
27 dated 20 March 2003 to USACE-Mobile District stating that UXO avoidance is no longer needed  
28 for Choccolocco Corridor of FTMC.

29  
30 At the completion of the RI field work and review of the sample data, Shaw will conduct a  
31 feasibility study (FS). The FS will identify, develop, screen, and evaluate remedial alternatives  
32 for contaminated media at the site as required under the Comprehensive Environmental  
33 Response, Compensation, and Liability Act (CERCLA). The FS report will be prepared in  
34 accordance with the guidelines, criteria, and considerations set forth in the 1988 U.S.  
35 Environmental Protection Agency guidance document entitled *Guidance for Conducting*  
36 *Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final*. The FS will

- 1 provide the BCT sufficient data to select a feasible and cost-effective remedial alternative that
- 2 will protect human health and the environment.
- 3

## 1.0 Project Description

---

### 1.1 Introduction

The U.S. Army is conducting studies of the environmental impact of suspected contaminants at Fort McClellan (FTMC) in Calhoun County, Alabama, under the management of the U.S. Army Corps of Engineers (USACE)-Mobile District. The USACE has contracted Shaw Environmental, Inc. (Shaw) (formerly IT Corporation [IT]) to provide environmental services for the remedial investigation (RI) at the Former Choccolocco Corridor Ranges: Former Range 40, Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q; Former Range 41, Parcel 95Q and Impact Area, Choccolocco Corridor, Parcel 131Q-X; Former Range 42, Parcel 96Q, Range, Choccolocco Corridor, Parcel 145Q-X, and Impact Area, Choccolocco Corridor, Parcel 148Q-X; and Former Range 43, Parcel 97Q, Range, Choccolocco Corridor, Parcel 144Q-X, and Impact Area, Choccolocco Corridor, Parcel 147Q-X (Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels) under Task Order CK10, Contract Number DACA21-96-D-0018.

The Former Choccolocco Corridor Ranges include the following four sets of ranges and parcels:

- Former Range 40, Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q,
- Former Range 41, Parcel 95Q and Impact Area, Parcel 131Q-X,
- Former Range 42, Parcel 96Q; Range, Choccolocco Corridor, Parcel 145Q-X, and Impact Area, Choccolocco Corridor, Parcel 148Q-X
- Former Range 43, Parcel 97Q, Range, Choccolocco Corridor, Parcel 144Q-X; and Impact Area, Choccolocco Corridor, Parcel 147Q-X

This RI site-specific field sampling plan (SFSP) has been prepared to provide technical guidance and rationale for sample collection and analysis at the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels. The objective of this investigation is to further characterize the potential contamination resulting from training activities that occurred at the sites and to better define the extent of potential groundwater contamination observed during previous investigations. Shaw will collect samples to characterize the source, nature, and extent of contamination. The data collected will also be used to evaluate the level of risk to human health and the environment posed by releases of chemicals. This RI SFSP will be used in conjunction with the site-specific safety and health plan (SSHP), the installation-wide sampling

and analysis plan (SAP) (IT, 2002a), and the installation-wide work plan (IT, 2002b). The SAP includes the installation-wide safety and health plan, well installation and maintenance plan, investigation-derived waste (IDW) management plan, ordnance and explosives (OE) management plan, and quality assurance plan (QAP). Site-specific hazard analysis is included in the SSHP attachment.

## **1.2 FTMC Site Description and History**

FTMC is located in the foothills of the Appalachian Mountains of northeastern Alabama near the cities of Anniston and Weaver in Calhoun County. FTMC is approximately 60 miles northeast of Birmingham, 75 miles northwest of Auburn, and 95 miles west of Atlanta, Georgia. FTMC consists of three main areas of government-owned and leased properties: the Main Post, Pelham Range, and Choccolocco Corridor (the lease for Choccolocco Corridor terminated in May 1998). The size of each property is presented below:

- |                        |              |
|------------------------|--------------|
| • Main Post            | 18,929 acres |
| • Pelham Range         | 22,245 acres |
| • Choccolocco Corridor | 4,488 acres. |

The Main Post is bounded on the east by the Choccolocco Corridor, which connects the Main Post with the Talladega National Forest. Pelham Range is located approximately five miles west of the Main Post and adjoins the Anniston Army Depot on the southwest. Pelham Range is located to the west of U.S. Highway 431, approximately five miles from the Main Post.

FTMC is under the jurisdiction of the U.S. Army Training and Doctrine Command. Until September 1999, the installation housed three major organizations, the U.S. Army Military Police School, the U.S. Army Chemical School, and the Training Center (under the direction of the training brigade), in addition to other major support units and tenants.

In 1917 the U.S. government purchased 18,929 acres of land near Anniston for use as an artillery range and a training camp due to the outbreak of World War I. The site was named Camp McClellan in honor of Major General George B. McClellan, a leader of the Union Army during the Civil War. Camp McClellan was used to train troops for World War I from 1917 until the armistice. It was then designated as a demobilization center. Between 1919 and 1929, Camp McClellan served as a training area for active army units and other civilian elements. Camp McClellan was redesignated as Fort McClellan in 1929 and continued to serve as a training area.

In 1940, the government acquired an additional 22,245 acres west of FTMC. This tract of land was named Pelham Range. In 1941, the Alabama legislature leased approximately 4,488 acres to

the U.S. government to provide an access corridor from the Main Post to Talladega National Forest. This corridor provided access to additional woodlands for training.

The U.S. Army operated the Chemical Corps School at FTMC from 1951 until the school was deactivated in 1973. The Chemical Corps School offered advanced training in all phases of chemical, biological, and radiological warfare to students from all branches of the military service.

Until closure in September 1999, activities at FTMC could be divided into support activities, academic training, and practical training. Support activities included housing, feeding, and moving individuals during training. Academic training included classroom, laboratory, and field instruction. Practical training included weapons, artillery and explosives, vehicle operation and maintenance, and physical and tactical training activities.

### ***1.3 Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels: Site Description and History***

The Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels are located west of the Choccolocco Mountains in Choccolocco Corridor near the eastern boundary of the FTMC Main Post (Figure 1-1). The Former Choccolocco Corridor Ranges were part of the Range 40 complex. The Choccolocco Corridor was leased by the U.S. government from the State of Alabama from 1941 until 1998. The Choccolocco Corridor lease was terminated in May 1998, and the land is currently managed by the Alabama Forestry Commission. The information presented on the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels was compiled from the *Final Environmental Baseline Survey, Fort McClellan, Alabama*, (EBS) (Environmental Science and Engineering, Inc. [ESE], 1998), the *Archives Search Report, Fort McClellan, Anniston, Alabama* (ASR) (USACE, 2001), and site walks conducted by Shaw personnel in December 2001 and January 2002.

#### ***Former Range 40, Parcel 94Q; and Range, Choccolocco Corridor, Parcel 146Q.***

Former Range 40, Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q, overlap and the area of investigation for both parcels includes approximately 125 acres. Former Range 40, Parcel 94Q, a former small arms range, is described in the ASR (USACE, 2001) as 30 acres in size (EBS map shows a parcel of 25 acres) (Figure 1-2).

Interviews with former FTMC personnel indicated that Former Range 40, Parcel 94Q, was used for small arms training during World War II, the Korean War, and the Vietnam War. The

1 direction of fire was reported to be to the west; however, the firing line identified by the EBS, the  
2 dimensions of Range 40 on the ASR maps, and field observations during the site walks suggest a  
3 northwesterly fire direction. Evidence of smoke training has also been observed in the vicinity  
4 of this former range (ESE, 1998).

5 Site walks conducted by Shaw personnel in December 2001 and January 2002 found numerous  
6 features, some of which appear to be range-related. The locations of these features are presented  
7 on Figure 1-2. The observed features included:

- 8
- 9 • A dismantled helicopter adjacent to the northwestern portion of the area of
- 10 investigation for Parcel 94Q
- 11
- 12 • Coils of barbed (razor) wire
- 13
- 14 • Several broken-down wooden signs
- 15
- 16 • A deep pit with two large mounds nearby
- 17
- 18 • Several swing-up targets with electrical conduit running to the northwest/southeast
- 19
- 20 • Several target mounds, a deep bunker, and electrical connections
- 21
- 22 • A possible electrical connection for a pop-up target control
- 23
- 24 • A stationary target
- 25
- 26 • Shallow depressions, some with wooden debris
- 27
- 28 • Several northeast/southwest-oriented low berms.
- 29

30 In addition to the above features, trees had been removed to address the southern pine beetle  
31 infestation from several areas adjacent to the existing roads in the northwestern portion of the  
32 area of investigation. A clear-cut area was also observed in the eastern portion of the area of  
33 investigation for Parcel 94Q.

34

35 Range, Choccolocco Corridor, Parcel 146Q, identified in the EBS as approximately 102 acres in  
36 size, is a presumed small arms range. This parcel overlaps with Parcel 94Q. A portion of the  
37 southeastern corner of Parcel 146Q extends beyond the FTMC Choccolocco Corridor lease  
38 boundary to the south (Figure 1-2).

39

Parcel 146Q is presumed to be a small arms range because cratered impact areas were not observed. The Environmental Photographic Interpretation Center (EPIC) reports that this range appears to be active in aerial photographs dated 1949, 1954, and 1972 (ESE, 1998).

Site walks conducted by Shaw personnel in December 2001 and January 2002 within the area of investigation for Parcel 146Q noted numerous features, some of which appear to be range-related. The locations of these features are presented on Figure 1-2 and include:

- A number of circular depressions, some up to 10 feet wide and 5 feet deep
- A pole with dangling electrical wires
- An apparent target pit
- Several trenches in the southwestern portion of the parcel
- Several coils of barbed (razor) wire
- Half of a rusted drum just outside the southwestern parcel border.

***Former Range 41, Parcel 95Q; and Impact Area, Choccolocco Corridor, Parcel 131Q-X.***

The area of investigation for Parcels 95Q and 131Q-X is approximately 12 acres (Figure 1-2). Former Range 41, Parcel 95Q, is 8.5 acres in size. There are conflicting reports of the dates of use for Parcel 95Q, but the area was most likely active during the 1960s and 1970s. The history of use for Former Range 41 is unclear. The range appeared on 1966 and 1971 historical maps, which would coincide with reports from long-time FTMC personnel who indicate that this range was a small arms range during the Vietnam era. Direction of fire is believed to have been toward the west (ESE, 1998).

The ASR indicates that Former Range 41 was built during the Vietnam War, was listed as a Battle Drill & Assault Range, probably did not include live fire, and was abandoned by 1974 (USACE, 2001). Expended M-16 rifle blanks, smoke grenades, and 40 millimeter (mm) TP grenade cases were found on this range, as indicated in the ASR.

Parcel 131Q-X is described as a former impact area within the Range 40 area. Parcel 131Q-X is 4.4 acres in size (ESE, 1998).

Site walks by Shaw personnel conducted in December 2001 and January 2002 at Former Range 41 revealed that the area appears to have been used for training. The most obvious feature noted during the site walk was a large berm, possibly a backstop, situated along the southwest and west parcel boundaries (Figure 1-2). The berm varied in height from 10 to 30 feet. At the west end of Former Range 41, two cleared areas were found in front of the berm. In the open areas, vegetation was mostly young montane longleaf pine (*Pinus palustris*). Expended shell casings

1 and evidence of 40mm grenade casings were found in these cleared areas. A depression (2 feet x  
2 4 feet x 1 foot deep), a 55-gallon drum (used for small arms target practice), and expended flares  
3 were found to the south of the berm, in the southeast corner of Parcel 95Q. An observation  
4 tower was noted to the west of the road, within Parcel 131Q-X. A depression (2 feet x 4 feet x 1  
5 foot deep) was found to the west of the observation tower. On the east side of the road, a berm 3  
6 feet high runs in a northwest-southeast direction adjacent and parallel to a 4-foot-deep ditch. The  
7 fuselage of a helicopter was found to the west of Parcel 95Q; however, there was no evidence it  
8 had been used as a target. Remnants of a building with exposed electrical wiring were observed  
9 to the southeast of the parcels. It is possible that pop-up targets were controlled from this  
10 location. Areas to the south and west of the parcels, partially bounded by dirt roads, show  
11 evidence of having been recently logged.

12  
13 **Former Range 42, Parcel 96Q; Range, Choccolocco Corridor, Parcel 145Q-X; and**  
14 **Impact Area, Choccolocco Corridor, Parcel 148Q-X.** The ASR states that Former Range  
15 42, Parcel 96Q, was built during the Vietnam War era and was known as the Squad Defense  
16 Range (USACE, 2001). However, some FTMC personnel remember the area being used during  
17 World War II and the Korean War. According to the ASR, the range was abandoned by 1974.  
18 Former Range 42 is 23.8 acres according to the EBS (the ASR states the range was 6 acres) and  
19 was probably used during the 1960s and 1970s. Parcel 145Q-X was identified by EPIC and  
20 appears to be active in EPIC aerial photo composites dated 1949, 1954, and 1972 (a 1961 photo  
21 composite of Choccolocco Corridor was not included in the EPIC report).

22  
23 Range, Choccolocco Corridor, Parcel 145Q-X, is 44.1 acres. The southern boundary of Parcel  
24 145Q-X overlaps Former Range 41, Parcel 95Q (Figure 1-2). Large-caliber weapons are  
25 presumed to have been fired at Parcel 145Q-X, because cratered impact areas were identified  
26 within the range areas. Parcel 145Q-X, identified by EPIC, is located in the vicinity of the  
27 Range 40 complex, which was previously identified from maps. It is possible that the mapped  
28 locations were planned locations that were subsequently constructed in a different orientation.

29  
30 The EBS lists Impact Area, Choccolocco Corridor, Parcel 148Q-X, as an impact area that  
31 occupies 5.8 acres within Parcels 96Q and 145Q-X.

32  
33 Shaw personnel conducting a site visit at Parcels 96Q, 145Q-X, and 148Q-X, in December 2001  
34 concluded that this area had been used for military training. Several target bunkers for pop-up  
35 targets were identified in the central portion of the range. Electrical system remnants and old  
36 target structures were also noted in several places. An old electrical substation/building was  
37 identified near the northern boundary of Parcel 96Q. Offensive firing pits and the main firing

1 line (east side of the range) were also identified. The main firing line was built up approximately  
2 10 feet higher than the surrounding area, and remnants were seen of shooting boxes 2 feet x 3  
3 feet x 6 feet deep built behind a bermed area. There was not any typical small arms range debris  
4 (e.g., casings, bullets) identified in the Parcel 96Q area. Some expended flares, empty drums,  
5 and empty cylinders were found next to a swampy area located in the eastern portion of Parcel  
6 145Q-X, outside of the area of Parcel 96Q. A trench and area of shallow depressions were also  
7 found in this area (Figure 1-2).

8  
9 **Former Range 43, Parcel 97Q; Range, Choccolocco Corridor, Parcel 144Q-X; and**  
10 **Impact Area, Choccolocco Corridor, Parcel 147Q-X.** Former Range 43, Parcel 97Q, is  
11 identified as a former small arms range. The EBS identifies Range 43 as approximately 4 acres  
12 in size; however, in the ASR, Range 43 is reported as approximately 7 acres in size. The area of  
13 investigation for Parcel 97Q will be expanded beyond the parcel boundaries identified in the  
14 EBS, based upon the results of the site walk and review of aerial photographs. The area of  
15 investigation for Parcel 97Q consists of approximately 9 acres.

16  
17 Approximately two-thirds of Parcel 97Q is located within the boundaries of Range, Choccolocco  
18 Corridor, Parcel 144Q-X. The Parcel 97Q range was previously designated as Range 43 and  
19 Range 3, but the dimensions of these previous ranges are not documented in the EBS. Interviews  
20 with long time FTMC personnel indicated that the Parcel 97Q range was used for small arms  
21 training during World War II, the Korean War, and the Vietnam War. The direction of fire was  
22 reported to be to the west; however, the firing line identified by the EBS for this range suggests a  
23 southwesterly fire direction. Evidence of smoke training has also been observed in the vicinity  
24 of this former range (ESE, 1998).

25  
26 Site walks conducted at Parcel 97Q by Shaw personnel in December 2001 and January 2002  
27 revealed several features that appear to be related to range-training activities (Figure 1-2). These  
28 features included the following:

- 29
- 30 • A line of firing positions or target pits spaced at approximately 20-foot intervals  
31 was observed slightly to the east of Parcel 97Q. The approximate dimensions  
32 were 2 feet by 3 feet by 6 feet deep. The walls were supported by wooden  
33 framework. These features are presumed to have been used as firing positions or  
34 target pits. The location of these features appears to be to the east of the Parcel  
35 97Q firing line identified in the EBS.
  - 36  
37 • Numerous 5.56mm blanks were observed near an overgrown road in the western  
38 area of Parcel 97Q.
- 39

- Numerous wood-framed target boxes were observed on the hillside southwest of the Parcel 97Q boundary identified in the EBS. The target boxes appear to be linearly oriented in several northwest/southeast-trending lines.
- An end-of-range sign (black and white diagonal) is located approximately 550 feet southwest of the western boundary of Parcel 97Q identified in the EBS.

Range, Choccolocco Corridor, Parcel 144Q-X, identified as a former range, is approximately 19 acres in size. Parcel 144Q-X encompasses about two thirds of Parcel 97Q and most of Impact Area, Choccolocco Corridor, Parcel 147Q-X. The presence of cratered impact areas within the range area suggests that large caliber weapons may have been fired toward Parcel 144Q-X (ESE, 1998). This range appears to be active in EPIC aerial photographs dated 1949, 1954, and 1972 (ESE, 1998).

Site walks conducted by Shaw personnel in December 2001 and January 2002 revealed several possible range-related features within the boundary of Parcel 144Q-X. One of these features is located within the boundaries of Parcel 147Q-X. Most of Parcel 147Q-X is located within the boundaries of Parcel 144Q-X. The locations of these features are illustrated on Figure 1-2. The observed features are:

- An observation tower is located in the east-central portion of the parcel, near the northwestern edge of Parcel 147Q-X.
- An airframe mock-up is located in the north-central portion of Parcel 144Q-X on the path of horse trail. The horse trail goes through the airframe. There are not any bullet holes observed in the airframe, suggesting that it has not been used as a target for range training.
- A series of firing positions or target pits are located to the east of Parcel 97Q (described above in the Parcel 97Q description).
- An area of depressions is located in the northeastern area of Parcel 147Q-X. The depressions are approximately 3 to 6 feet wide by 2 feet deep. An ammunition box was present in the bottom of one depression. An expended 40mm flare and an expended pop flare were present near the depressions. It is speculated that these depressions were used as foxholes for firing positions.

Impact Area, Parcel 147Q-X, is identified as a former impact area, approximately 3 acres in size. It is not known which range is associated with this impact area. This parcel is located within the boundaries of Parcel 144Q-X.

## **1.4 Regional and Site-Specific Geology**

### **1.4.1 Regional Geology**

Calhoun County includes parts of two physiographic provinces, the Piedmont Upland Province and the Valley and Ridge Province. The Piedmont Upland Province occupies the extreme eastern and southeastern portions of the county and is characterized by metamorphosed sedimentary rocks. The generally accepted range in age of these metamorphics is Cambrian to Devonian.

The majority of Calhoun County, including the Main Post of FTMC, lies within the Appalachian fold-and-thrust structural belt (Valley and Ridge Province), where southeastward-dipping thrust faults with associated minor folding are the predominant structural features. The fold-and-thrust belt consists of Paleozoic sedimentary rocks that have been asymmetrically folded and thrust-faulted, with major structures and faults striking in a northeast-southwest direction.

Northwestward transport of the Paleozoic rock sequence along the thrust faults has resulted in the imbricate stacking of large slabs of rock, referred to as thrust sheets. Within an individual thrust sheet, smaller faults may splay off the larger thrust fault, resulting in imbricate stacking of rock units within the individual thrust sheet (Osborne and Szabo, 1984). Geologic contacts in this region generally strike parallel to the faults, and repetition of lithologic units is common in vertical sequences. Geologic formations within the Valley and Ridge Province portion of Calhoun County have been mapped by Warman and Causey (1962), Osborne and Szabo (1984), and Moser and DeJarnette (1992) and vary in age from Lower Cambrian to Pennsylvanian.

The basal unit of the sedimentary sequence in Calhoun County is the Cambrian Chilhowee Group. The Chilhowee Group consists of the Cochran, Nichols, Wilson Ridge, and Weisner Formations (Osborne and Szabo, 1984) but in Calhoun County is either undifferentiated or divided into the Cochran and Nichols Formations and an upper, undifferentiated Wilson Ridge and Weisner Formation. The Cochran is composed of poorly sorted arkosic sandstone and conglomerate with interbeds of greenish gray siltstone and mudstone. Massive to laminated greenish gray and black mudstone makes up the Nichols Formation, with thin interbeds of siltstone and very fine-grained sandstone (Osborne et al., 1988). These two formations are mapped only in the eastern part of the county.

The Wilson Ridge and Weisner Formations are undifferentiated in Calhoun County and consist of both coarse-grained and fine-grained clastics. The coarse-grained facies appears to dominate the unit and consists primarily of coarse-grained, vitreous quartzite and friable, fine- to coarse-

1 grained, orthoquartzitic sandstone, both of which locally contain conglomerate. The fine-grained  
2 facies consists of sandy and micaceous shale and silty, micaceous mudstone, which are locally  
3 interbedded with the coarse clastic rocks. The abundance of orthoquartzitic sandstone and  
4 quartzite suggests that most of the Chilhowee Group bedrock in the vicinity of FTMC belongs to  
5 the Weisner Formation (Osborne and Szabo, 1984).

6  
7 The Cambrian Shady Dolomite overlies the Weisner Formation northeast, east, and southwest of  
8 the Main Post and consists of interlayered bluish gray or pale yellowish gray sandy dolomitic  
9 limestone and siliceous dolomite with coarsely crystalline, porous chert (Osborne et al., 1989).  
10 A variegated shale and clayey silt have been included within the lower part of the Shady  
11 Dolomite (Cloud, 1966). Material similar to this lower shale unit was noted in core holes drilled  
12 by the Alabama Geologic Survey on FTMC (Osborne and Szabo, 1984). The character of the  
13 Shady Dolomite in the FTMC vicinity and the true assignment of the shale at this stratigraphic  
14 interval are still uncertain (Osborne, 1999).

15  
16 The Rome Formation overlies the Shady Dolomite and locally occurs to the northwest and  
17 southeast of the Main Post, as mapped by Warman and Causey (1962) and Osborne and Szabo  
18 (1984), and immediately to the west of Reilly Airfield (Osborne and Szabo, 1984). The Rome  
19 Formation consists of variegated, thinly interbedded grayish red-purple mudstone, shale,  
20 siltstone, and greenish red and light gray sandstone, with locally occurring limestone and  
21 dolomite. Weaver Cave, located approximately one mile west of the northwest boundary of the  
22 Main Post, is situated in gray dolomite and limestone mapped as the Rome Formation (Osborne  
23 et al., 1997). The Conasauga Formation overlies the Rome Formation and occurs along  
24 anticlinal axes in the northeastern portion of Pelham Range (Warman and Causey, 1962;  
25 Osborne and Szabo, 1984) and the northern portion of the Main Post (Osborne et al., 1997). The  
26 Conasauga Formation is composed of dark gray, finely to coarsely crystalline, medium- to thick-  
27 bedded dolomite with minor shale and chert (Osborne et al., 1989).

28  
29 Overlying the Conasauga Formation is the Knox Group, which is composed of the Copper Ridge  
30 and Chepultepec dolomites of Cambro-Ordovician age. The Knox Group is undifferentiated in  
31 Calhoun County and consists of light medium gray, fine to medium crystalline, variably bedded  
32 to laminated, siliceous dolomite and dolomitic limestone that weather to a chert residuum  
33 (Osborne and Szabo, 1984). The Knox Group underlies a large portion of the Pelham Range  
34 area.

35  
36 The Ordovician Newala and Little Oak Limestones overlie the Knox Group. The Newala  
37 Limestone consists of light to dark gray, micritic, thick-bedded limestone with minor dolomite.

1 The Little Oak Limestone consists of dark gray, medium- to thick-bedded, fossiliferous,  
2 argillaceous to silty limestone with chert nodules. These limestone units are mapped as  
3 undifferentiated at FTMC and in other parts of Calhoun County. The Athens Shale overlies the  
4 Ordovician limestone units. The Athens Shale consists of dark gray to black shale and  
5 graptolitic shale with localized interbedded dark gray limestone (Osborne et al., 1989). These  
6 units occur within an eroded “window” in the uppermost structural thrust sheet at FTMC and  
7 underlie much of the developed area of the Main Post.

9 Other Ordovician-aged bedrock units mapped in Calhoun County include the Greensport  
10 Formation, Colvin Mountain Sandstone, and Sequatchie Formation. These units consist of  
11 various siltstones, sandstones, shales, dolomites, and limestones and are mapped as one,  
12 undifferentiated unit in some areas of Calhoun County. The only Silurian-age sedimentary  
13 formation mapped in Calhoun County is the Red Mountain Formation. This unit consists of  
14 interbedded red sandstone, siltstone, and shale with greenish gray to red silty and sandy  
15 limestone.

17 The Devonian Frog Mountain Sandstone consists of sandstone and quartzitic sandstone with  
18 shale interbeds, dolomudstone, and glauconitic limestone (Osborne et al., 1988). This unit  
19 locally occurs in the western portion of Pelham Range.

21 The Mississippian Fort Payne Chert and the Maury Formation overlie the Frog Mountain  
22 Sandstone and are composed of dark to light gray limestone with abundant chert nodules and  
23 greenish gray to grayish red phosphatic shale, with increasing amounts of calcareous chert  
24 toward the upper portion of the formation (Osborne and Szabo, 1984). These units occur in the  
25 northwestern portion of Pelham Range. Overlying the Fort Payne Chert is the Floyd Shale, also  
26 of Mississippian age, which consists of thin-bedded, fissile, brown to black shale with thin  
27 intercalated limestone layers and interbedded sandstone. Osborne and Szabo (1984) reassigned  
28 the Floyd Shale, which was mapped by Warman and Causey (1962) on the Main Post of FTMC,  
29 to the Ordovician Athens Shale based on fossil data.

31 The Pennsylvanian Parkwood Formation overlies the Floyd Shale and consists of a medium to  
32 dark gray, silty, clay shale and mudstone with interbedded light to medium gray, very fine to fine  
33 grained, argillaceous, micaceous sandstone. Locally the Parkwood Formation also contains beds  
34 of medium to dark gray argillaceous, bioclastic to cherty limestone and beds of clayey coal up to  
35 a few inches thick (Raymond et al., 1988). In Calhoun County, the Parkwood Formation is  
36 generally found within a structurally complex area known as the Coosa deformed belt. In the  
37 deformed belt, the Parkwood Formation and Floyd Shale are mapped as undifferentiated because

1 their lithologic similarity and significant deformation make it impractical to map the contact  
2 (Thomas and Drahovzal, 1974; Osborne et al., 1988). The undifferentiated Parkwood Formation  
3 and Floyd Shale are found throughout the western quarter of Pelham Range.

4  
5 The Jacksonville thrust fault is the most significant structural geologic feature in the vicinity of  
6 the Main Post of FTMC, both for its role in determining the stratigraphic relationships in the area  
7 and for its contribution to regional water supplies. The trace of the fault extends northeastward  
8 for approximately 39 miles between Bynum, Alabama, and Piedmont, Alabama. The fault is  
9 interpreted as a major splay of the Pell City fault (Osborne and Szabo, 1984). The Ordovician  
10 sequence that makes up the Eden thrust sheet is exposed at FTMC through an eroded window, or  
11 "fenster," in the overlying thrust sheet. Rocks within the window display complex folding, with  
12 the folds being overturned and tight to isoclinal. The carbonates and shales locally exhibit well-  
13 developed cleavage (Osborne and Szabo, 1984). The FTMC window is framed on the northwest  
14 by the Rome Formation; north by the Conasauga Formation; northeast, east, and southwest by  
15 the Shady Dolomite; and southeast and southwest by the Chilhowee Group (Osborne et al.,  
16 1997). Two small klippen of the Shady Dolomite, bounded by the Jacksonville fault, have been  
17 recognized adjacent to the Pell City fault at the FTMC window (Osborne et al., 1997).

18  
19 The Pell City fault serves as a fault contact between the bedrock within the FTMC window and  
20 the Rome and Conasauga Formations. The trace of the Pell City fault is also exposed  
21 approximately nine miles west of the FTMC window on Pelham Range, where it traverses  
22 northeast to southwest across the western quarter of Pelham Range. The trace of the Pell City  
23 fault marks the boundary between the Pell City thrust sheet and the Coosa deformed belt.

24  
25 The eastern three-quarters of Pelham Range is located within the Pell City thrust sheet, while the  
26 remaining western quarter of Pelham is located within the Coosa deformed belt. The Pell City  
27 thrust sheet is a large-scale thrust sheet containing Cambrian and Ordovician rocks. It is  
28 relatively less structurally complex than the Coosa deformed belt (Thomas and Neathery, 1982).  
29 The Pell City thrust sheet is exposed between the traces of the Jacksonville and Pell City faults  
30 along the western boundary of the FTMC window and along the trace of the Pell City fault on  
31 Pelham Range (Thomas and Neathery, 1982; Osborne et al., 1988). The Coosa deformed belt is  
32 a narrow northeast-to-southwest-trending linear zone of complex structure (approximately 5 to  
33 20 miles wide and approximately 90 miles in length) consisting mainly of thin imbricate thrust  
34 slices. The structure within these imbricate thrust slices is often internally complicated by small-  
35 scale folding and additional thrust faults (Thomas and Drahovzal, 1974).

#### 1.4.2 Site-Specific Geology

Soils at the Former Choccolocco Corridor Ranges fall mainly into six mapping units: Stony Rough Land sandstone (Ss), Anniston and Allen stony loams, Anniston and Allen gravelly loams, Anniston gravelly clay loam, Jefferson gravelly fine sandy loam, and Philo and Stendall soils, local alluvium (U.S. Department of Agriculture [USDA], 1961).

Stony Rough Land sandstone (Ss) consists of well-drained, shallow, stony, friable, medium to strongly acidic soils. Slopes generally are more than 25 percent. Erosion has been slight to severe, and some of the slopes have lost all of their original surface soil. The soil material is generally shallow over bedrock. Runoff is high, permeability is moderate to rapid, infiltration is slow, and the capacity for available moisture is low. The depth to bedrock is typically less than 2.5 feet, with depth to water exceeding 20 feet below ground surface (bgs) (USDA, 1961).

The Anniston and Allen Series of soils consists of strongly acidic, deep, well-drained soils that have developed in old local alluvium. The parent material washed from the adjacent higher-lying Linker, Muskingum, Enders, and Montevallo soils, which developed from weathered sandstone, shale, and quartzite. Sandstone and quartzite gravel and cobbles, measuring as much as 8 inches in diameter, are common throughout the soil. For this soil series, the depth to bedrock is typically from 2 feet to greater than 10 feet, with depth to water greater than 20 feet. Some severely eroded areas may be common on the surface for this soil type, as well as a few shallow gullies. The typical soil description is 2 to 10 feet of well-drained stony loam to clay loam over stratified local alluvium, limestone or shale bedrock (USDA, 1961).

Anniston and Allen stony loams, 10 to 25 percent slopes (AdE), consist of a very dark brown to very dark grayish brown stony loam surface layer 4 to 8 inches thick. At a depth of about 10 inches, this material grades into a dark red or dark reddish brown stony fine sandy clay loam. These soils are not well suited to cultivation due to the stoniness and strong slopes, and therefore most of the acreage is woodland (USDA, 1961).

Anniston and Allen gravelly loams include 2 to 6 percent slopes, eroded (AcB2) and 6 to 10 percent slopes, eroded (AcC2). They consist of friable soils that have developed in old alluvium on foot slopes and along the base of mountains. The color of the surface soil ranges from very dark brown and dark brown to reddish brown and dark reddish brown. The texture of subsoil ranges from light clay loam to clay or silty clay loam. Infiltration and runoff are medium, permeability is moderate, and the capacity for available moisture is high. The physical properties of this unit make it suitable for cultivation, but erosion is high because of the strong slopes (USDA, 1961).

1  
2 Anniston gravelly clay loam, 2 to 6 percent slopes, severely eroded (AbB3) consists of a reddish  
3 brown gravelly clay loam layer 4 to 6 inches thick, underlain in most places by red or dark  
4 reddish brown gravelly clay loam. These soils have poor tilth, moderately slow infiltration, and  
5 a low capacity to hold moisture. Due to these characteristics and the gravel content, the  
6 agricultural capability of the soil is limited (USDA, 1961).

7  
8 The Jefferson gravelly fine sandy loam soil consists of well-drained, strongly acidic soils that  
9 occur in small areas on fans and foot slopes. These soils have developed from old local alluvium  
10 that washed or sloughed from ridges of sandstone, shale, and Weisner quartzite. The surface soil  
11 is dark grayish brown fine sandy loam, and the subsoil is yellowish brown, light fine sandy clay.  
12 Fragments of sandstone and quartzite are found on the surface and throughout the soil (USDA,  
13 1961).

14  
15 The Philo and Stendal soils, local alluvium, occur in areas 1 to 10 acres in size on foot slopes and  
16 at the heads of small drainage ways. The soils are variable in color, texture, and consistency; but  
17 generally the surface soils are dark grayish brown to dark brown fine sandy loam and the subsoil  
18 is dark brown, slightly mottled fine sandy loam. The parent material washed mainly from  
19 sandstone and shale, but some originated from limestone. The drainage ranges from somewhat  
20 poor to moderately good (USDA, 1961).

21  
22 Bedrock was not encountered during drilling at the Former Choccolocco Corridor Ranges,  
23 however, bedrock in the vicinity of the ranges is mapped as the undifferentiated Chilhowee  
24 Group in the northwestern area, Shady Dolomite in the central area, and Rome Formation to the  
25 southeast (Figure 1-3). The undifferentiated Chilhowee Group consists of a basal unit of arkosic  
26 conglomerate and mudstone overlain by a unit of greenish gray mudstone with minor siltstone  
27 and sandstone. The sequence grades upward into a white to moderately reddish orange friable  
28 sandstone and conglomerate containing interbedded gray silty mudstone (Raymond et al., 1988).  
29 The undifferentiated Chilhowee Group is overlain by the Shady Dolomite. The Shady Dolomite  
30 is typically bluish gray thick-bedded, medium crystalline limestone and light to dark gray,  
31 argillaceous to sandy, massive to laminated dolomite with a local unit of silty clay and clayey  
32 siltstone at the base (Raymond et al., 1988). The Shady Dolomite is overlain by the Rome  
33 Formation to the east. The Rome Formation consists of variegated thinly interbedded grayish  
34 red-purple mudstone, shale, siltstone, and greenish red and light gray sandstone, with locally  
35 occurring limestone and dolomite (Raymond et al., 1988).

1 **Parcels 94Q and 146Q.** The residuum encountered during drilling activities at Parcels 94Q  
2 and 146Q was described as light brown to yellowish orange clay and silt with some sand and  
3 some gravel (sandstone and quartzite) or light brown to yellowish orange fine to medium sand  
4 and silt with some clay and little gravel (also sandstone and quartzite). Hollow-stem auger  
5 refusal was encountered at depths of 22.5 and 27 feet bgs at HR-146Q-MW01 and HR-146Q-  
6 MW02, respectively. The residuum encountered prior to refusal was described as light brown to  
7 yellowish orange clay and sand with little quartzite gravel.

9 **Parcels 95Q and 131Q-X.** The residuum encountered during drilling activities at Parcels 95Q  
10 and 131Q-X consisted of light brown clay with some sand and little silt and sandstone gravel and  
11 reddish brown clay and silt with little sand and sandstone gravel. Hollow-stem auger refusal was  
12 encountered at one location, HR-131Q-MW01, at a depth of 52 feet bgs. Residuum encountered  
13 prior to refusal was described as brown clay with some gray siltstone gravel and little sand.

15 **Parcels 96Q, 145Q-X, and 148Q-X.** The residuum encountered during drilling activities at  
16 Parcels 96Q, 145Q-X, and 148Q-X consisted of light brown to yellowish orange clay with some  
17 fine to coarse sand, little subangular sandstone and quartzite gravel, and trace silt. Hollow-stem  
18 auger refusal was not encountered during drilling activities at Parcels 96Q, 145Q-X, and 148Q-  
19 X.

21 **Parcel 97Q, 144Q, and 147Q-X.** The residuum encountered in shallow borings was typically  
22 described as medium dark brown to reddish brown clay and silt with some quartzite and  
23 sandstone gravel and little sand. The residuum encountered during drilling activities at well  
24 locations was described as yellowish orange, reddish brown, and light brown clay with varying  
25 amounts of silt, sand, and sandstone gravel. Hollow-stem auger refusal was encountered at  
26 depths of 30 and 46 feet bgs at HR-144Q-MW01 and HR-147Q-MW02, respectively. The  
27 residuum encountered prior to refusal were described as light brown to yellowish orange clay  
28 and weathered sandstone gravel with some sand and little silt.

30 The boring logs are included in Appendix A. The drilling and sampling activities proposed in  
31 this RI sampling plan will provide additional lithological information for these sites.

## 33 **1.5 Regional and Site-Specific Hydrogeology**

### 35 **1.5.1 Regional Hydrogeology**

36 The hydrogeology of Calhoun County has been investigated by the Geologic Survey of Alabama  
37 (Moser and DeJarnette, 1992), the U.S. Geological Survey (Warman and Causey, 1962), and the

Alabama Department of Environmental Management (ADEM) (Planert and Pritchette, 1989). Groundwater in the vicinity of FTMC occurs in residuum derived from bedrock decomposition, within fractured bedrock along fault zones, and from the development of karst frameworks. Groundwater flow may be estimated to be toward major surface water features. Areas with well-developed residuum horizons may subtly reflect the surface topography, but the groundwater flow direction also may exhibit the influence of pre-existing structural fabrics or the presence of perched water horizons on unweathered ledges or impermeable clay lenses.

Precipitation and subsequent infiltration provide recharge to the groundwater flow system in the region. The main recharge areas for the aquifers in Calhoun County are located in the valleys. The ridges generally consist of sandstone, quartzite, and slate, which are resistant to weathering, relatively unaffected by faulting, and therefore relatively impermeable. The ridges have steep slopes and thin to no soil cover, which enhances runoff to the edges of the valleys (Planert and Pritchette 1989).

The thrust fault zones typical of the county form large storage reservoirs for groundwater. Points of discharge occur as springs, effluent streams, and lakes. Coldwater Spring is one of the largest springs in the State of Alabama, with a discharge of approximately 32 million gallons per day. This spring is the main source of water for the Anniston Water Department, from which FTMC buys its water. The spring is located approximately five miles southwest of Anniston and discharges from the brecciated zone of the Jacksonville Fault (Warman and Causey, 1962).

Shallow groundwater on FTMC occurs principally in the residuum developed from Cambrian sedimentary and carbonate bedrock units of the Weisner Formation, Shady Dolomite, and locally in lower Ordovician carbonates. The residuum may yield adequate groundwater for domestic and livestock needs but may go dry during prolonged dry weather. Bedrock permeability is locally enhanced by fracture zones associated with thrust faults and by the development of solution (karst) features.

Two major aquifers were identified by Planert and Pritchette (1989): the Knox-Shady and Tuscumbia-Fort Payne aquifers. The continuity of the aquifers has been disrupted by the complex geologic structure of the region, such that each major aquifer occurs repeatedly in different areas. The Knox-Shady aquifer group occurs over most of Calhoun County and is the main source of groundwater in the county. It consists of the Cambrian- and Ordovician-aged quartzite and carbonates. The Conasauga Dolomite is the most utilized unit of the Knox-Shady aquifer, with twice as many wells drilled as any other unit (Moser and DeJarnette, 1992).

1 Regional groundwater flow in the bedrock was approximated for the FTMC vicinity by the U.S.  
2 Geological Survey (Scott et al., 1987). Regional groundwater elevation ranges from 800 feet  
3 above mean sea level on the main Base to about 600 feet above mean sea level to the west on  
4 Pelham Range, based on water depths in wells completed across multiple formations.  
5 Groundwater elevation contours suggest that regional groundwater flow from the Main Post is to  
6 the northwest.

7  
8 Scott et al. (1987) concluded that the groundwater surface broadly coincides with the surface  
9 topography and that the regional aquifers are hydraulically connected. Groundwater flow on a  
10 local scale may be more complex and may be affected by geologic structures such as the shallow  
11 thrust faults, rock fracture systems, and karst development in soluble formations.

### 13 **1.5.2 Site-Specific Hydrogeology**

14 Static groundwater levels measured in monitoring wells at the Former Choccolocco Corridor  
15 Ranges on October 18, 2002, are summarized in Table 1-1. Depth-to-groundwater  
16 measurements were taken from the top of casing following procedures outlined in the SAP (IT,  
17 2002a). A groundwater elevation map was constructed from the October 2002 data, as shown on  
18 Figure 1-4. Based on the water level data collected at the Former Choccolocco Corridor Ranges,  
19 groundwater flow in the residuum is generally to the east and southeast.

### 21 **1.6 Scope of Work**

22 The scope of work for activities associated with the RI for the Former Choccolocco Corridor  
23 Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels as specified by the USACE  
24 statement of work (USACE, 2002) includes the following tasks:

- 25 • Develop the RI SFSP attachment.
- 26
- 27 • Develop the RI SSHP attachment.
- 28
- 29 • Conduct a six-phase investigation approach, including:
  - 30 1. Conduct x-ray fluorescence (XRF) survey of surface soil to determine
  - 31 locations of soil borings and monitoring wells (approximately 700 locations).
  - 32
  - 33 2. Install 50 soil borings to collect one surface soil and two subsurface soil
  - 34 samples at each boring (a total of 50 surface soil samples and 100 subsurface
  - 35 soil samples).
  - 36
  - 37 3. Collect surface soil samples from 50 locations for only surface soil, to be
  - 38 determined based on XRF surface soil screening results.
  - 39
  - 40
  - 41

4. Install 10 residuum monitoring wells
  5. Collect 25 groundwater samples from 10 proposed residuum monitoring wells and 15 existing monitoring wells.
  6. Collect 30 surface water and 30 sediment samples.
- Analyze samples for the parameter methods listed in Section 4.6.
  - Conduct a feasibility study (FS), as directed by the Base Realignment and Closure (BRAC) Cleanup Team (BCT), in accordance with the guidelines, criteria, and considerations set forth in the U.S. Environmental Protection Agency (EPA) 1988 guidance document entitled *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*.

Foster Wheeler Environmental Corporation conducted an OE engineering evaluation/cost analysis (EE/CA) investigation in 2002 and 2003. The purpose of the EE/CA was to investigate the nature and extent of unexploded ordnance and ordnance (UXO) and OE in Charlie Area (includes Choccolocco Corridor) on FTMC. Based on the results of the field work, USACE-Huntsville Center has issued an internal draft EE/CA report that states that neither UXO nor OE was found within Choccolocco Corridor. Therefore, the USACE-Huntsville Center issued a memorandum dated 20 March 2003 to USACE-Mobile District stating that UXO avoidance is no longer needed for Choccolocco Corridor at FTMC. A copy of the memorandum by USACE-Huntsville Center is attached to this SFSP as Attachment 2.

At the completion of the field activities and sample analyses, draft, draft final, and final RI summary reports will be prepared. Reports will be prepared in accordance with current EPA Region 4 and ADEM requirements.

Subsequent to completion of the RI field work, an FS will be conducted for the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels to identify, develop, screen, and evaluate remedial alternatives for contaminated media at the site, as required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and as specified in the National Oil and Hazardous Substances Contingency Plan (40 *Code of Federal Regulations*, Part 300). An FS report will be prepared in accordance with the guidelines, criteria, and considerations set forth in the EPA guidance document entitled *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The report will provide the BCT sufficient data to select a feasible and cost-effective remedial alternative that will protect human health and the environment.

1  
2 The sections in the FS report will provide the following:

- 3  
4 • An introduction detailing site background information and a summary of the RI,  
5 including the nature and extent of contamination, contaminant fate and transport,  
6 and the results of the human health and ecological risk assessments  
7  
8 • Identification and screening of remedial technologies  
9  
10 • Development and screening of remedial alternatives  
11  
12 • A detailed analysis of remedial alternatives.  
13

14 The Identification and Screening of Technologies section of the report will present objectives for  
15 remedial action(s), a summary of applicable health and environmental protection criteria and  
16 standards, and identification of volumes or areas of media to which remedial actions may be  
17 applied. It will also identify general response actions for each medium of interest, defining  
18 containment, treatment, excavation, or other actions, singly or in combination, that may be taken  
19 to satisfy the remedial action objectives. Potentially feasible technologies will be presented for  
20 each of the general response actions, along with the technical criteria and the site-specific  
21 requirements used in the technology screening process and the results of the remedial technology  
22 screening.  
23

24 The Development and Screening of Remedial Alternatives section of the report will present the  
25 remedial alternatives developed by combining the technologies carried forward from the initial  
26 screening. Each of the identified alternatives will be screened against three evaluation criteria:  
27 1) effectiveness, 2) implementability, and 3) cost.  
28

29 The Detailed Analysis of Remedial Alternatives section will present a description and evaluation  
30 of each of the alternatives retained from the alternative screening process. Each alternative will  
31 be evaluated individually, and a comparative analysis among alternatives will be presented. The  
32 remedial action alternatives selected for evaluation will be individually evaluated against the  
33 following seven criteria:

- 34  
35 • Overall protection of human health and the environment  
36 • Compliance with applicable or relevant and appropriate requirements  
37 • Long-term effectiveness and permanence  
38 • Reduction of toxicity, mobility, and volume  
39 • Short-term effectiveness  
40 • Implementability

- Cost.

Although CERCLA requires the evaluation of alternatives against nine evaluation criteria, the state acceptance and community acceptance criteria will be evaluated in the record of decision after comments have been received on the FS report from the regulatory agencies and the public.

## 2.0 Summary of Existing Environmental Studies

---

An EBS was conducted by ESE to document current environmental conditions of all FTMC property (ESE, 1998). The study was to identify sites that, based on available information, have no history of contamination and comply with U.S. Department of Defense guidance for fast-track cleanup at closing installations. The EBS also provides a baseline picture of FTMC properties by identifying and categorizing the properties by seven criteria.

1. Areas where no storage, release, or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent areas).
2. Areas where only release or disposal of petroleum products has occurred.
3. Areas where release, disposal, and/or migration of hazardous substances has occurred, but at concentrations that do not require a removal or remedial response.
4. Areas where release, disposal, and/or migration of hazardous substances has occurred, and all removal or remedial actions to protect human health and the environment have been taken.
5. Areas where release, disposal, and/or migration of hazardous substances has occurred, and removal or remedial actions are underway, but all required remedial actions have not yet been taken.
6. Areas where release, disposal, and/or migration of hazardous substances has occurred, but required actions have not yet been implemented.
7. Areas that are not evaluated or require additional evaluation.

The EBS was conducted in accordance with protocols of the Community Environmental Response Facilitation Act (CERFA) (CERFA-Public Law 102-426) and policy of the U.S. Department of Defense regarding contamination assessment. Record searches and reviews were performed on all reasonably available documents from FTMC, ADEM, EPA Region 4, and Calhoun County, as well as a database search of CERCLA-regulated substances, petroleum products, and facilities regulated by the Resource Conservation and Recovery Act. Available historical maps and aerial photographs were reviewed to document historical land uses. Personal and telephone interviews of past and present FTMC employees and military personnel were conducted. In addition, visual site inspections were conducted to verify conditions of specific property parcels.

1 The Former Choccolocco Corridor Ranges were identified as CERFA Category 1 Qualified  
2 parcels. CERFA Category 1 Qualified parcels are sites where no known or recorded storage,  
3 release, or disposal (including migration) has occurred on site property. Some of the parcels,  
4 however, were qualified “X” because chemicals of potential concern and/or UXO may be present  
5 as a result of historical range activities.-Therefore, these parcels required additional evaluation to  
6 determine their environmental condition

7  
8 The following sections summarize site investigation (SI) activities conducted by Shaw at the  
9 Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels,  
10 including environmental sampling and analysis and groundwater monitoring well installation  
11 activities. The scope of the SI was outlined in the SFSPs for the Former Choccolocco Corridor  
12 Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels (IT, 2002c,d,e,f).

## 13 14 **2.1 Site Investigation**

15 The purpose of the SIs conducted at the Former Choccolocco Corridor Ranges was to determine  
16 the presence or absence of potential site-specific chemicals and to recommend further actions, if  
17 appropriate. The scope of the SIs was outlined in the following documents:

- 18  
19 • *Final Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and*  
20 *Site-Specific Unexploded Ordnance Safety Plan Attachments, Former Range 40,*  
21 *Parcel 94Q, and Range, Choccolocco Corridor, Parcel 146Q (IT, 2002c).*  
22
- 23 • *Final Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and*  
24 *Site-Specific Unexploded Ordnance Safety Plan Attachments, Former Range 41,*  
25 *Parcel 95Q and Impact Area, Choccolocco Corridor, Parcel 131Q-X (IT, 2002d).*  
26
- 27 • *Final Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and*  
28 *Site-Specific Unexploded Ordnance Safety Plan Attachments, Former Range 42,*  
29 *Parcel 96Q; Range, Choccolocco Corridor, Parcel 145Q-X, and Impact Area,*  
30 *Choccolocco Corridor, Parcel 148Q-X (IT, 2002e).*  
31
- 32 • *Final Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and*  
33 *Site-Specific Unexploded Ordnance Safety Plan Attachments, Former Range 43,*  
34 *Parcel 97Q; Range, Choccolocco Corridor, Parcel 144Q-X, and Impact Area,*  
35 *Choccolocco Corridor, Parcel 147Q-X (IT, 2002f).*  
36

37 Detailed information on the SI activities conducted at each range is reported in the following  
38 documents:

- 39  
40 • *Draft Site Investigation Report, Former Range 40, Parcel 94Q, and Range,*  
41 *Choccolocco Corridor, Parcel 146Q (Shaw, 2003a).*

- *Draft Site Investigation Report, Former Range 41, Parcel 95Q, and Impact Area, Choccolocco Corridor, Parcel 131Q-X* (Shaw, 2003b).
- *Draft Site Investigation Report, Former Range 42, Parcel 96Q; Range, Choccolocco Corridor, Parcel 145Q-X, and Impact Area, Choccolocco Corridor, Parcel 148Q-X* (Shaw, 2003c).
- *Draft Site Investigation Report, Former Range 43, Parcel 97Q; Range, Choccolocco Corridor, Parcel 144Q-X, and Impact Area, Choccolocco Corridor, Parcel 147Q-X* (Shaw, 2003d).

The following sections summarize the SI activities conducted at the Former Choccolocco Corridor Ranges.

### **2.1.1 Summary of Field Activities**

SI field activities at the Former Choccolocco Corridor Ranges consisted of the collection and analysis of 72 surface soil samples, 17 depositional soil samples, 70 subsurface soil samples, 12 groundwater samples, 3 surface water samples, and 3 sediment samples. In addition, 15 monitoring wells were installed to facilitate groundwater sample collection and to provide site-specific geological and hydrogeological characterization information. The sample locations, media, and rationale for the SIs at the Former Choccolocco Corridor Ranges are summarized in Table 2-1. SI sampling locations are shown on Figure 2-1. Sample collection logs and chain of custody (COC) records are included in the SI reports for the Former Choccolocco Corridor Ranges.

Samples collected during the SIs at the Former Choccolocco Corridor Ranges were analyzed for the following parameters using EPA SW-846 methods, including Update III methods where applicable:

- Target analyte list metals – EPA Methods 6010B/7470A/7471A
- Nitroaromatic/nitramine explosives – EPA Method 8330.

A minimum of ten percent of the samples were analyzed for the following additional parameters:

- Target compound list (TCL) volatile organic compounds (VOC) – EPA Method 8260B
- TCL semivolatile organic compounds (SVOC) – EPA Method 8270C
- Chlorinated herbicides – EPA Method 8151A
- Chlorinated pesticides – EPA Method 8081A
- Organophosphorus pesticides – EPA Method 8141A.

1 In addition, the sediment samples were analyzed for total organic carbon content (Walkley-Black  
2 method) and grain size (American Society for Testing and Materials Method D-422).

3  
4 Environmental sampling at the Former Choccolocco Corridor Ranges was performed following  
5 procedures outlined in the SI SFSPs (IT, 2002c,d,e,f) as attachments to the installation-wide  
6 work plan (IT, 2002b) and SAP. The monitoring wells were installed and developed as  
7 described in the SAP. The lithological logs and well construction logs are included in Appendix  
8 A. Table 1-1 summarizes construction details of the monitoring wells installed at the parcels.  
9 Well development logs are included in the SI reports for the Former Choccolocco Corridor  
10 Ranges. Table 2-2 summarizes the groundwater and surface water field parameters.

11  
12 Sample locations were surveyed using global positioning system (GPS) and conventional civil  
13 survey techniques described in the SAP. Horizontal coordinates were referenced to the U.S.  
14 State Plane Coordinate System, Alabama East Zone, North American Datum of 1983.  
15 Elevations were referenced to the North American Vertical Datum of 1988. Horizontal  
16 coordinates and elevations are included in the SI reports for the Former Choccolocco Corridor  
17 Ranges. Horizontal coordinates and elevations are included in Appendix B.

### 18 19 **2.1.2 Summary of Analytical Results**

20 The results of the chemical analyses of samples collected at the Former Choccolocco Corridor  
21 Ranges indicate that metals, VOCs, SVOCs, pesticides, two herbicides, and explosive  
22 compounds were detected in various site media. To evaluate whether the detected constituents  
23 pose an unacceptable risk to human health and the environment, the analytical results were  
24 compared to human health site-specific screening levels (SSSL), ecological screening values  
25 (ESV), and background for FTMC. The SSSLs and ESVs were developed by Shaw as part of  
26 the human health and ecological risk evaluations associated with SIs being performed under the  
27 BRAC Environmental Restoration Program at FTMC. The SSSLs and ESVs are presented in the  
28 *Final Human Health and Ecological Screening Values and PAH Background Summary Report*  
29 (IT, 2000). BTVs are presented in the *Final Background Metals Survey Report, Fort McClellan,*  
30 *Alabama* (Science Applications International Corporation, 1998).

31  
32 For metals, comparing on-site concentrations of constituents to background constitutes tier 1 of  
33 the three-tiered background screening process. Tiers 2 and 3 of the background screening  
34 process entail statistical comparisons and geochemical evaluations to determine whether  
35 constituents are naturally occurring or are site-related. The data collected and evaluated as part  
36 of the RI described in this SFSP will be subjected to the three-tier background screening  
37 evaluation process. In order to determine whether contamination is present within the study area

1 and to guide the sampling and analysis described in this SFSP, historical data were evaluated  
2 using only tier 1 of the background screening process

3  
4 The following sections and Tables 2-3 through 2-7 summarize the results of the comparison of  
5 the detected constituents to the SSSLs, ESVs, and background. Complete analytical data are  
6 presented in the SI reports for the Former Choccolocco Corridor Ranges.

#### 7 8 **2.1.2.1 Surface and Depositional Soil Analytical Results**

9 A total of 72 surface soil samples and 17 depositional soil samples were collected at the Former  
10 Choccolocco Corridor Ranges. Surface and depositional soil samples were collected from the  
11 uppermost foot of soil at the locations shown on Figure 2-1. Analytical results were compared to  
12 residential human health SSSLs, ESVs, and metals background values, as presented in Table 2-3.

13  
14 **Metals.** A total of 23 metals were detected in the surface and depositional soil samples  
15 collected at the Former Choccolocco Corridor Ranges. Of these, 11 metals (aluminum,  
16 antimony, barium, cadmium, chromium, copper, iron, lead, manganese, thallium, and zinc)  
17 exceeded SSSLs and their respective background values in one or more samples. Figures  
18 showing the surface and depositional soil sample locations with metals results exceeding SSSLs  
19 and background are presented in the SI reports for the Former Choccolocco Corridor Ranges  
20 (Shaw, 2003a,b,c,d).

21  
22 A total of 17 metals were detected at concentrations exceeding ESVs. Of these, aluminum,  
23 antimony, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese,  
24 mercury, selenium, thallium, and zinc also exceeded their respective background concentrations  
25 in one or more samples. Figures showing the sample locations with metals results exceeding  
26 ESVs and background in surface and depositional soils are presented in the SI reports.

27  
28 Lead was the most significant metal concentration detected in surface soil and depositional soil  
29 samples and was detected at concentrations (401 to 4,640 mg/kg) exceeding its residential SSSL  
30 (400 mg/kg) in 19 samples. Figure 2-2 shows the estimated lead concentration isopleths for  
31 surface soil and depositional soil at the Former Choccolocco Ranges based on the sample data  
32 presented in Table 2-3.

33  
34 **Volatile Organic Compounds.** Thirteen surface and depositional soil samples were  
35 analyzed for VOCs. A total of five VOCs (2-butanone, acetone, p-cymene, toluene, and  
36 trichlorofluoromethane) were detected in the samples at concentrations below their respective  
37 SSSLs and ESVs.

**Semivolatile Organic Compounds.** Thirteen surface and depositional soil samples were analyzed for SVOCs. Three SVOCs (di-n-butyl phthalate, 2,4-dinitrotoluene, and n-nitrosodiphenylamine) were detected at one sample location (HR-96Q-GP04) at concentrations below their respective SSSLs and ESVs.

**Pesticides.** Thirteen surface and depositional soil samples were analyzed for pesticides. A total of 18 pesticides were detected in the samples. The detected pesticide concentrations were all below SSSLs; however, concentrations of 9 pesticides (4,4'-dichlorodiphenyldichloroethene [DDE], 4,4'-dichlorodiphenyltrichloroethane [DDT], aldrin, alpha-hexachlorocyclohexane [BHC], beta-BHC, dieldrin, endrin, gamma-BHC, and methoxychlor) exceeded their respective ESVs.

**Herbicides.** Thirteen surface and depositional soil samples were analyzed for herbicides. Two herbicides (2,4-dichlorophenoxyacetic acid and propionic acid [MCP]) were detected in one sample each (HR-144Q-GP04 and HR-97Q-GP04, respectively). The herbicide results were below SSSLs; however, the MCP result (2.2 milligrams per kilogram [mg/kg]) exceeded its ESV (0.1 mg/kg).

**Explosives.** The explosive 2,4-dinitrotoluene was detected at two sample locations (HR-144Q-GP03 and HR-96Q-GP04). The 2,4-dinitrotoluene result (1.5 mg/kg) at sample location HR-96Q-GP04 exceeded its SSSL (0.93 mg/kg) and ESV (1.28 mg/kg).

#### **2.1.2.2 Subsurface Soil Analytical Results**

A total of 70 subsurface soil samples were collected at the Former Choccolocco Corridor Ranges, as shown on Figure 2-1. Analytical results were compared to residential human health SSSLs and metals background concentrations, as presented in Table 2-4.

**Metals.** A total of 23 metals were detected in the subsurface soil samples. The concentrations of eight metals (aluminum, antimony, chromium, iron, lead, manganese, thallium, and vanadium) exceeded SSSLs and background concentrations. Figures showing the subsurface soil sample locations with metals results exceeding SSSLs and background are presented in the SI reports.

**Volatile Organic Compounds.** Ten subsurface soil samples were analyzed for VOCs. A total of four VOCs (acetone, 2-butanone, p-cymene, and toluene) were detected in the samples at concentrations below their respective SSSLs.

**Semivolatile Organic Compounds.** Ten subsurface soil samples were analyzed for SVOCs. Two SVOCs (fluoranthene and n-nitrosodiphenylamine) were detected at one sample location (HR-96Q-GP04) at estimated concentrations below their respective SSSLs.

**Pesticides.** Ten subsurface soil samples were analyzed for pesticides. A total of five pesticides (4,4'-DDT, dieldrin, heptachlor, alpha-chlordane, and gamma-chlordane) were detected in the samples at estimated concentrations below their respective SSSLs.

**Herbicides.** Ten subsurface soil sample locations were analyzed for herbicides. Herbicides were not detected in the subsurface soil samples.

**Explosives.** Two explosive compounds (2,4-dinitrotoluene and 2-amino-4,6-dinitrotoluene) were detected at one subsurface soil sample location each (HR-131Q-GP01 and HR-144Q-GP03, respectively) at estimated concentrations below their respective SSSLs.

### **2.1.2.3 Groundwater Analytical Results**

Twelve groundwater samples were collected for chemical analysis at the Former Choccolocco Corridor Ranges, at the locations shown on Figure 2-1. Analytical results were compared to residential human health SSSLs and metals background values, as presented in Table 2-5.

**Total Metals.** Fourteen metals (aluminum, arsenic, barium, calcium, cobalt, copper, iron, lead, magnesium, manganese, potassium, selenium, sodium, and zinc) were detected in the groundwater samples collected at the site. Of these, four metals (aluminum, arsenic, iron, and manganese) exceeded their respective SSSLs in one or more samples. The metals results were below background with the exception manganese (1.69 milligrams per liter [mg/L]), which exceeded its SSSL (0.0735 mg/L) and background (0.581 mg/L) at one sample location (HR-145Q-MW02).

**Dissolved Metals.** One groundwater sample location (HR-94Q-MW01) was analyzed for dissolved metals. Ten metals were detected in the sample. Iron and manganese exceeded their respective SSSLs, but the results were below background.

**Volatile Organic Compounds.** Three groundwater samples were analyzed for VOCs. One VOC, methylene chloride, was detected at one groundwater sample location (HR-148Q-MW01) at a concentration below its SSSL.

1 **Semivolatile Organic Compounds.** Three groundwater sample locations were analyzed for  
2 SVOCs. SVOCs were not detected in the groundwater samples.

3  
4 **Pesticides.** Three groundwater sample locations were analyzed for pesticides. Pesticides were  
5 not detected in the groundwater samples.

6  
7 **Herbicides.** Three groundwater sample locations were analyzed for herbicides. Herbicides  
8 were not detected in the groundwater samples.

9  
10 **Explosives.** Two explosive compounds (1,3,5-trinitrobenzene and 2,4,6-trinitrotoluene) were  
11 detected at one groundwater sample location each (HR-148Q-MW01 and HR-96Q-MW01,  
12 respectively) at estimated concentrations below their respective SSSLs.

### 13 14 **2.1.3 Surface Water**

15 Three surface water samples were collected at the Former Choccolocco Corridor Ranges, as  
16 shown on Figure 2-1. Analytical results were compared to recreational site user SSSLs, ESVs,  
17 and background values, as presented in Table 2-6.

18  
19 **Metals.** A total of 11 metals (aluminum, barium, calcium, cobalt, copper, iron, lead,  
20 magnesium, manganese, potassium, and sodium) were detected in the three surface water  
21 samples. The detected metals results were below SSSLs. The concentrations of five metals  
22 (aluminum, barium, cobalt, copper, and lead) exceeded their respective ESVs but were below  
23 background. (Note: a background value for cobalt was not available).

24  
25 **Volatile Organic Compounds.** One surface water sample location (HR-95Q-SW/SD01) was  
26 analyzed for VOCs. One VOC (methylene chloride) was detected in the sample at a  
27 concentration below its SSSL and ESV.

28  
29 **Semivolatile Organic Compounds.** One surface water sample location (HR-95Q-  
30 SW/SD01) was analyzed for SVOCs. SVOCs were not detected in the surface water sample.

31  
32 **Pesticides.** One surface water sample location (HR-95Q-SW/SD01) was analyzed for  
33 pesticides. Pesticides were not detected in the surface water sample.

34  
35 **Herbicides.** One surface water sample location (HR-95Q-SW/SD01) was analyzed for  
36 herbicides. Herbicides were not detected in the surface water sample.

1 **Explosives.** One surface water sample location (HR-95Q-SW/SD01) was analyzed for  
2 explosives. Explosives were not detected in the surface water sample.

#### 3 4 **2.1.4 Sediment**

5 Three sediment samples were collected at the same locations as the surface water samples, as  
6 shown on Figure 2-1. Analytical results were compared to recreational site user SSSLs, ESVs,  
7 and background, as presented in Table 2-7.

8  
9 **Metals.** Eighteen metals were detected in the three sediment samples collected at the sites.  
10 These metals results were below their respective SSSLs. The concentrations of copper (in one  
11 sample) and lead (in two samples) exceeded their respective ESVs. The lead results were below  
12 background. The copper result (29.5 mg/kg) exceeded its ESV (18.7 mg/kg) and background  
13 (17.1 mg/kg) at sample location HR-131Q-SW/SD01.

14  
15 **Volatile Organic Compounds.** One sediment sample location (HR-95Q-SW/SD01) was  
16 analyzed for VOCs. Acetone was detected in the sample at an estimated concentration below its  
17 SSSL and ESV.

18  
19 **Semivolatile Organic Compounds.** One sediment sample location (HR-95Q-SW/SD01)  
20 was analyzed for SVOCs. SVOCs were not detected in the sediment sample.

21  
22 **Pesticides.** One sediment sample location (HR-95Q-SW/SD01) was analyzed for pesticides.  
23 Pesticides were not detected in the sediment sample.

24  
25 **Herbicides.** One sediment sample location (HR-95Q-SW/SD01) was analyzed for herbicides.  
26 Herbicides were not detected in the sediment sample.

27  
28 **Explosives.** One sediment sample location (HR-95Q-SW/SD01) was analyzed for explosives.  
29 Explosives were not detected in the sediment sample.

#### 30 31 **2.1.5 SI Summary and Conclusions**

32 Comparison of the analytical data to the SSSLs, ESVs, and background indicates the human  
33 health chemicals of potential concern at the Former Choccolocco Corridor Ranges are 11 metals  
34 (aluminum, antimony, barium, cadmium, chromium, copper, iron, lead, manganese, thallium,  
35 and zinc) and one explosive compound (2,4-dinitrotoluene) in surface and depositional soils; 8  
36 metals (aluminum, antimony, chromium, iron, lead, manganese, thallium, and vanadium) in  
37 subsurface soil; and manganese in groundwater. The most significant chemical of potential

1 concern is lead, which was detected at concentrations (401 to 4,640 mg/kg) exceeding its  
2 residential SSSL (400 mg/kg) in 19 surface soil and depositional soil samples and 2 subsurface  
3 soil samples. VOC, SVOC, herbicide, and pesticide concentrations in site media were below  
4 SSSLs.

5  
6 Constituents of potential ecological concern include 15 metals (aluminum, antimony, barium,  
7 beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, selenium,  
8 thallium, and zinc), 9 pesticides (4,4'-DDE, 4,4'-DDT, aldrin, alpha-BHC, beta-BHC, dieldrin,  
9 endrin, gamma-BHC, and methoxychlor), one herbicide (MCPP), and one explosive compound  
10 (2,4-dinitrotoluene) in surface soil; and copper in sediment. No constituents of potential  
11 ecological concern were identified in surface water.

12  
13 Based on the results of the SI, past training operations at the Former Choccolocco Corridor  
14 Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels appear to have adversely impacted  
15 the environment. The contaminants detected in soil may pose an unacceptable risk to human  
16 health and the environment. The SI data for the Former Choccolocco Corridor Ranges were  
17 presented to the BCT in January 2003. Therefore, the BCT recommended that the nature and  
18 extent of the metals contamination in soil be defined at the Former Choccolocco Corridor  
19 Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels. Also, the BCT agreed that the 15  
20 existing monitoring wells at the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q,  
21 97Q, and Associated Parcels will be resampled to verify the previous SI results and that ten  
22 additional monitoring wells will be installed and sampled to determine if contaminants are  
23 present. Because of proximity of the ranges and because lead contamination was found in  
24 surface soil at each of the four sites, the BCT recommended combining the four range areas into  
25 one RI.

## 3.0 Site-Specific Data Quality Objectives

---

### 3.1 Overview

The data quality objective (DQO) process is followed to establish data requirements. This process ensures that the proper quantity and quality of data are generated to support the decision-making process associated with the future action for the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels. This section incorporates the components of the DQO process described in the EPA publication *Guidance for the Data Quality Objectives Process* (EPA, 2000). The DQO process as applied to the Former Choccolocco Corridor Ranges is described in more detail in Section 3.4 of this RI SFSP. Table 3-1 provides a summary of the factors used to determine the appropriate quantity of samples and the procedures necessary to meet the objectives of the RI and establish a basis for future action at this site.

To support the RI at the Former Choccolocco Corridor Ranges, five sample media will be collected for analysis: groundwater, surface soil, subsurface soil, surface water, and sediment. The samples will be analyzed for this RI using EPA SW-846 methods, including Update III Methods where applicable, as presented in Chapter 4.0 in this RI SFSP and Section 5.0 of the QAP. Data will be reported in accordance with the definitive data requirements of the USACE Engineer Manual, *Chemical Quality Assurance for Hazardous, Toxic and Radioactive Waste (HTRW) Projects* (USACE, 1997) and evaluated by the stipulated requirements for the generation of definitive data (Section 7.2.2 of the QAP). Chemical data will be reported by the laboratory via hard-copy data packages using Contract Laboratory Program-like forms along with electronic copies. These packages will be validated in accordance with EPA National Functional Guidelines Level III criteria.

### 3.2 Data Users and Available Data

The available data related to the RI SFSP at the Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels presented in Table 3-1, have been used to formulate a site-specific conceptual model. This conceptual model was developed to support the development of this RI SFSP, which is necessary to meet the objectives of these activities and to establish a basis for future action at the site. The data users for information generated during field activities are primarily EPA, USACE, ADEM, FTMC, and the USACE supporting contractors. This RI SFSP, along with the necessary companion documents, has been designed to provide the regulatory agencies with sufficient detail to reach a determination as to the adequacy of the scope of work. The program has also been designed to provide defensible

information required to confirm or deny the existence and nature of residual chemical contamination in site media.

### **3.3 Conceptual Site Exposure Model**

The conceptual site exposure model (CSEM) provides the basis for identifying and evaluating potential risks to human health and the environment in the risk assessment. The CSEM includes all receptors and potential exposure pathways appropriate to all plausible scenarios. The CSEM facilitates consistent and comprehensive evaluation of risk to human health and the environment through graphically presenting all possible exposure pathways, including all sources, release and transport pathways, and exposure routes. In addition, the CSEM helps to ensure that potential pathways are not overlooked. The elements of a complete exposure pathway and CSEM are:

- Source of contamination
- Source (i.e., initially contaminated environmental) media
- Contaminant release mechanisms
- Contaminant transport pathways
- Intermediate or transfer media
- Exposure media
- Receptors
- Exposure pathways.

Contaminant release mechanisms and transport pathways are not relevant for direct receptor contact with a contaminated source medium.

Primary contaminant release mechanisms probably reflect use of most of the parcels of interest as small arms firing ranges. The occasional presence of 55-gallon drums suggests that other training exercises may have been conducted that resulted in leaks and spills. Potential contaminant transport pathways include rain runoff and erosion to surface soil, infiltration and leaching to subsurface soil and groundwater, dust emissions and volatilization to ambient air, surface water runoff and erosion to surface water and sediment, and uptake in vegetation and biotransfer to deer through browsing and to ecological receptors through food web interactions.

#### **3.3.1 Current Site Use Receptors**

The Alabama Forestry Commission currently manages Choccolocco Corridor. The Former Choccolocco Corridor Ranges, Parcels 94Q, 95Q, 96Q, 97Q, and Associated Parcels are heavily wooded and are not currently used by Base personnel. The site is not fenced and, thus, is accessible to trespassers. Because trespassers or hunters may access the site, a recreational site user who hunts will be evaluated for the current human health land-use scenario. The site is no longer used for training, nor is it currently maintained by a groundskeeper. Therefore, the only

1 plausible human receptor evaluated under the current land-use scenario is the recreational site  
2 user who hunts. Fish ingestion will not be evaluated because the surface water is insufficient to  
3 support fish for consumption. Other potential human receptors considered, but not included  
4 under current land-use scenarios, are the:

- 5  
6 • **Construction Worker.** The site is unused, and no development or construction  
7 is occurring.
- 8  
9 • **Resident.** The site is not currently used for residential purposes.

### 11 **3.3.2 Future Site Use Receptors**

12 Future land use for the area of investigation is shown as remediation reserve to be used for  
13 passive recreation (EDAW, Inc., 1997). Recreation activities that may occur in the area are  
14 hiking, biking, horseback riding, and hunting. It is assumed that the sites are currently fully  
15 suitable for the proposed use and that excavation, grading, landscaping, building erection, and  
16 other construction activities will not be performed. Potential human receptor scenarios evaluated  
17 for the future include the following:

- 18  
19 • **Recreational Site User.** Because future land use is likely passive recreation,  
20 and hunting may be possible, the recreational site user who hunts is included.
- 21  
22 • **Resident.** Although the site is not expected to be used for residential purposes,  
23 the resident is considered in order to provide additional information for the project  
24 manager and regulators. The residential scenario generally represents the most  
25 conservative evaluation for long-term exposure to a site.

26  
27 A summary of relevant contaminant release and transport mechanisms, source and exposure media,  
28 and human receptor scenarios and exposure pathways for this site is provided in Table 3-1 and  
29 Figure 3-1.

30  
31 The environmental fate and transport of constituents in the various media within the  
32 Choccolocco Corridor are identical regardless of receptor type (human or ecological). The  
33 portion of the CSEM that differs for the ecological risk assessment is the receptors. Potential  
34 ecological receptors at the Choccolocco Corridor fall into two general categories: terrestrial and  
35 aquatic. Within these two general categories, there are several major feeding guilds that could be  
36 expected to occur within the Choccolocco Corridor: herbivores, invertivores, omnivores,  
37 carnivores, and piscivores. All of these feeding guilds are expected to be directly exposed via  
38 various activities (e.g., feeding, drinking, grooming, bathing) to various combinations of surface  
39 soil at the Former Choccolocco Corridor Ranges and surface water and sediment in the numerous

1 creeks that flow through this area. These feeding guilds may also be exposed to site-related  
2 chemicals via food web interactions.

3  
4 Dermal absorption of constituents from soil is a potential exposure pathway for all feeding guilds  
5 at the Choccolocco Corridor ranges; however, birds and mammals are less susceptible to dermal  
6 exposures because their feathers or fur prevents skin from coming into direct contact with the  
7 soil (EPA, 1993). Dermal absorption of inorganic compounds from direct contact with soil is  
8 expected to be minimal due to the low dermal permeability of these compounds. Likewise,  
9 dermal absorption of volatile constituents is expected to be minimal due to the fact that these  
10 constituents would volatilize rapidly from the skin surface before significant absorption could  
11 occur. Inhalation of VOCs is a viable exposure pathway, although it is expected to be  
12 insignificant due to the historical nature of these ranges and the fact that, if VOCs were present  
13 in soils, they would have likely volatilized over the years since these ranges were in active use.  
14 Inhalation of constituents sorbed to soil particles and inhaled as dust is a potential exposure  
15 pathway for all feeding guilds at the Former Choccolocco Corridor Ranges.

16  
17 Terrestrial species may also be exposed to constituents in surface water through ingestion of  
18 water in the numerous creeks that flow through the Former Choccolocco Corridor Ranges.  
19 Although these creeks are dry during certain periods of the year, over the course of years with  
20 normal levels of precipitation, they do hold standing and/or flowing water during portions of the  
21 year and could be utilized for drinking purposes.

22  
23 Aquatic and semiaquatic (i.e., amphibian) species have a greater potential for exposure to  
24 constituents in surface water and/or sediment, as they spend a majority of their lifetime in close  
25 proximity to water bodies. Aquatic and semiaquatic species could potentially be exposed to  
26 constituents in surface water and/or sediment via direct contact, ingestion of surface water and  
27 sediment, and ingestion of aquatic vegetation or aquatic invertebrates that may have accumulated  
28 site-related constituents.

29  
30 A summary of relevant contaminant release and transport mechanisms, source and exposure media,  
31 and ecological receptor scenarios and exposure pathways for this site is provided in Table 3-1 and  
32 Figure 3-2.

### 3.4 Decision-Making Process, Data Uses, and Needs

#### 3.4.1 Risk Evaluation

Data obtained from the sampling and analysis will be evaluated in a human health risk assessment and an ecological risk assessment. The first step in risk assessment, called background screening, distinguishes site-related chemicals from those present at concentrations comparable to background, because only site-related chemicals will be evaluated in the risk assessments. Background screening will be performed as a multi-tiered process as follows:

**Tier 1:** The maximum detected concentration (MDC) of a chemical detected in a given medium at the site is compared with the background, which is calculated as two times the mean of the background data set. Chemicals for which the MDC of site data does not exceed background are considered to be present at background concentrations, are not selected as site-related chemicals, and are not considered further in the risk assessment. Chemicals for which the MDC of site data exceeds background are carried forward to Tier 2.

**Tier 2:** Tier 2 consists of two statistical tests performed in parallel. One is the slippage test, which is used as a test of upper tails. The other is the Wilcoxon Rank Sum Test interpreted at the 80-percent confidence level. The use of these tests requires that the background and site data sets meet certain minimum standards (e.g., size). Chemicals which pass both statistical tests are considered to be present at background concentrations, are not selected as site-related chemicals, and are not considered further in the risk assessment. Chemicals for which either statistical test cannot be performed and chemicals that fail either statistical test are carried forward to Tier 3.

**Tier 3:** Tier 3 consists of a geochemical evaluation to determine whether concentrations of site metals are naturally occurring or are elevated due to contamination. The results of the geochemical evaluation will be reviewed by the appropriate regulatory offices or their delegates before the risk assessment is finalized.

The data evaluated as described above will be adequate for confirming the presence of site contamination and for supporting an FS and risk assessment. The protocols for the human health and ecological risk assessments are presented in Sections 5.2 and 5.3 of the work plan (IT, 2002b).

### **3.4.2 Data Types and Quality**

Surface soil, subsurface soil, groundwater, surface water, and sediment will be sampled and analyzed to meet the objectives of the RI at the Former Choccolocco Corridor Ranges. In association with these definitive samples, quality assurance/quality control (QA/QC) samples will be collected for sample types as described in Chapter 4.0 of this RI SFSP.

Samples will be analyzed by EPA-approved SW-846 methods Update III, where available, comply with EPA-definitive data requirements, and be reported using hard-copy data packages. In addition to meeting the quality needs of this RI SFSP, data analyzed at this level of quality are appropriate for all phases of site characterization, RI, and risk assessment.

### **3.4.3 Precision, Accuracy, and Completeness**

Laboratory requirements of precision, accuracy, and completeness for this RI SFSP are defined in Section 3.1 and presented in Section 5.0 of the QAP (IT, 2002a).